ANALYSIS OF A WASTE MINIMIZATION PROGRAM FOR NONHAZARDOUS SOLID WASTES UTILIZING SOURCE REDUCTION AND RECYCLING TECHNIQUES AND ITS APPLICATION TO AIR FORCE INSTALLATIONS

THESIS

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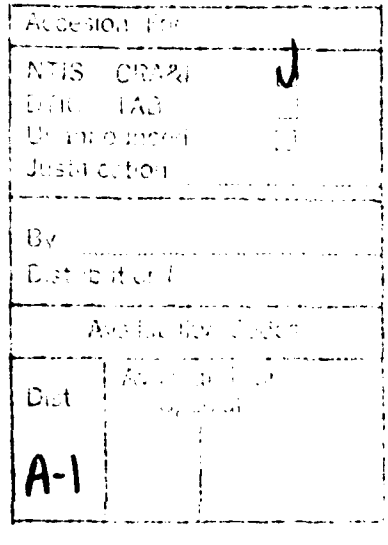

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THESIS

Presented to the Faculty of the School of Systems and Logistics

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Preface

The primary purpose of this research was to analyze the application of a waste minimization program for nonhazardous solid waste at Air Force installations. Installations generate a considerable amount of nonhazardous wastes which are normally disposed of by conventional methods. However, these methods are no longer effective or efficient. Most garbage from an installation is hauled away and deposited in landfills. This alternative is becoming more costly and has proven to be detrimental to the environment.

Waste minimization programs utilizing source reduction and recycling methods are considered the best way to combat the proliferation of garbage in our society. This research outlines what waste minimization is and how it can contribute to the reduction or even the elimination of waste. This research does not claim to answer all the questions. Hopefully, others will continue to do research in this area until the problems associated with nonhazardous solid waste are eradicated.

I would like to thank Dr. Panos Kokoropoulos, my thesis advisor, for giving me the flexibility to write this thesis my own way, and for also providing guidance when it was needed. Also, I would like to gratefully acknowledge my wife Wendy for all she has done over the years. Without her constant love and support I would not have been able to accomplish all that I have. My hope is that this thesis may make the world a better place for all, especially my daughter, Cate.

Brian McDermott

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Abstract

This nation has fallen victim to its own excessive behavior and has created an overabundance of trash, referred to in this thesis as nonhazardous solid waste (NHSW). This situation has created environmental and health problems that can no longer be ignored. All types of communities are affected including Air Force installations. Unfortunately, the Air Force does not currently have a long-term waste management policy or program regarding the minimization of NHSW. This research concentrates on the application of a NHSW minimization program for Air Force installations using the two most preferred methods, source reduction and recycling, which are most responsive to the desire of reducing the solid waste burden.

A review of the most current literature should provide the reader with sufficient background information into the specific problem statement. In addition, policy research was conducted to better equip Air Force policymakers with the necessary tools to combat the problems associated with NHSW. Based on the evidence presented in this thesis an urgent need exists to remedy the solid waste problem.

The development of a comprehensive waste minimization program using the techniques described is the most effective and efficient way to decrease the solid waste burden. The construction and implementation of these programs is not easy, especially for an organization as complex and diverse as the Air Force. However, the payoffs from a well planned and executed program far outweigh any costs.

ANALYSIS OF A WASTE MINIMIZATION PROGRAM FOR NONHAZARDOUS SOLID WASTES UTILIZING SOURCE REDUCTION AND RECYCLING TECHNIQUES AND ITS APPLICATION TO AIR FORCE INSTALLATIONS

I. Introduction

General Issue

Every year in the United States over six billion tons of commercial, industrial, agricultural, and domestic waste are placed in the solid waste stream (12:20). This overabundance of trash is extremely hazardous to the environment. Individuals, corporations, and governments are starting to realize that something needs to be done to reduce the amount of waste that is generated.

This nation has traditionally used the "end of pipe" method of waste management. This method concentrates on treating the waste after it has been generated and placed into the environment (4:71). In comparison, the concept of waste minimization is not to treat the waste after it has entered the solid waste stream, the end of pipe methodology. Instead, concern is focused on reducing the amount of waste that is put into the pipe (18:16-27).

The Air Force, like many large organizations, has not been 100 percent committed to reducing the amount of nonhazardous solid waste that it generates. The Air Force, through its employment of people, its use of many different types of equipment, and its application of industrial and manufacturing type processes contribute a significant amount of nonhazardous waste into the solid waste stream along with other Department of Defense (DoD) components. Air Force leaders have

been concentrating on the problems of hazardous waste disposal and minimization and have been remiss in placing the proper emphasis on the problems associated with nonhazardous solid waste generation.

The effects of hazardous waste generation have been well documented and publicized. Unfortunately, the same consideration has not been given to the effects of nonhazardous solid waste generation. In an 1986 report to Congress, the Environmental Protection Agency (EPA) stated that waste minimization is:

> The reduction to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either 1) the reduction of total volume or quantity of hazardous waste, or 2) the reduction of toxicity of hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment. (4:71)

Since this 1986 report, the definition of waste minimization has been expanded to include nonhazardous waste. Primary emphasis has been placed on hazardous waste because of its obvious health and environmental dangers, it should be noted, however, that nonhazardous solid waste also poses potential health, environmental, aesthetic, and financial threats and should be treated with equal emphasis.

There is a mounting solid waste problem and something needs to be done to rectify the situation. The Air Force is not removed from this problem and has to find a way to be actively involved in its correction.

Currently, the Air Force and the entire DoD community have committed a great deal of resources to minimize the generation of hazardous wastes. Additionally, Air Force leaders should acknowledge

the problems associated with nonhazardous solid waste and attempt to alleviate those problems. Such actions would benefit the environment, improve community relations, comply with local and federal regulations, and offer potential financial savings and/or benefits.

But,"How can the Air Force reduce its generation of nonhazardous solid waste?" Waste minimization is the most appropriate answer. Development of a comprehensive waste minimization program for nonhazardous wastes will help alleviate problems associated with generation and also provide long term benefits.

Specific Problem Statement

The Air Force does not currently have a long term waste management policy or program regarding the minimization of nonhazardous solid waste. There are bases which have developed in-house waste minimization programs which are normally limited to recycling aluminum cans, paper, and glass. These programs are beneficial, but are lacking in the scope necessary to combat the problem. Additionally, these programs are subject to failure if there is not an official Air Force policy designed to promote and foster participation and to protect the programs from commanders who are less than interested in waste minimization.

In September of 1989, Headquarters, Air Training Command hosted the first Air Force Waste Minimization Technology Transfer Conference. The conference showed that there is interest in the subject of waste minimization, however, the main emphasis was again placed on hazardous

waste. Nonhazardous waste generates the same types of problems as does hazardous waste; degradation of the environment, increased disposal and treatment costs, poor public relations, and health and safety risks. The main difference between the two waste streams is that hazardous waste problems are more time-sensitive and critical. However, this should not prevent the Air Force or all of DoD from adopting a comprehensive nonhazardous waste minimization policy.

Research Questions

1. What are the composition, size, and effects of nonhazardous solid waste?

2. What is waste minimization and how is a program developed?

3. What are the different techniques and methodologies used in a waste minimization program?

    3a. What are the details of source reduction?
    3b. What are the details of recycling?
    3c. What are the primary advantages and disadvantages of these waste minimization techniques?

4. How can a waste minimization program for nonhazardous wastes be developed and what are the applications to Air Force installations?

5. What are the advantages and disadvantages of a waste minimization program in both economic and environmental terms?

Scope of Research

In February 1989, the EPA produced a report entitled "The Solid Waste Dilemma: An Agenda for Action." This report outlined the objectives and strategies for a national solid waste management policy. The report suggested the use of an integrated waste management

hierarchy utilizing source reduction, recycling, treatment, and disposal. Source reduction and recycling are the most preferred methods within this hierarchy (23:1-11).

The scope of research for this thesis will concentrate on the application of a waste minimization program for nonhazardous solid waste utilizing source reduction and recycling techniques for Air Force installations. Source reduction implies that waste is both avoided and/or reduced at the source where it is generated (17:21-29). Recycling, a more recognizable term, is a management technique which enables waste products to be reused for some useful commercial or industrial purpose (4:72).

This research will only cover the most preferred methods of waste minimization, source reduction and recycling. The other methods within the hierarchy will not be addressed. Time constraints do not allow this research to uncover all the applications, advantages, and disadvantages associated with those other waste management methods. Moreover, source reduction and recycling, the preferred methods, are the most responsive to the desire of reducing the solid waste burden.

II. Literature Review

Solid Waste

An urgent need exists to remedy the solid waste problem. Experts have estimated that by the year 2000 the United States will generate 190 million tons of municipal solid waste (19:9-54). Municipal solid waste includes waste generated by the domestic and commercial sectors with the exception of sewer sludge waste (10:651). Each American contributes an average of 1300 pounds of garbage into the waste stream per year, which is approximately 3.5 pounds of garbage per day for every man, woman, and child (19:9-54).

Using 1988 figures, Table 1 depicts the materials generated in municipal solid waste by weight.

TABLE 1
BREAKDOWN OF MUNICIPAL SOLID WASTE GENERATED IN 1988, BY WEIGHT

MATERIAL	WEIGHT (in millions of tons)	PERCENT OF TOTAL GENERATED
PAPER	71.8	40.0
YARD WASTES	31.6	17.6
METALS	15.3	8.5
PLASTICS	14.4	8.0
FOOD WASTES	13.2	7.4
GLASS	12.5	7.0
OTHER	20.8	11.5
TOTAL	179.6	(21:5)

The popular waste management solution has been the use of landfills. Currently about 85 percent of all municipal solid waste is buried in landfills (30:67-72). There are approximately 6,034 landfills in the U.S. and more than 50 percent will be full in 1990 (31:57). The

problems currently associated with solid waste management are that landfill space is declining and disposal costs are increasing (30:67-72). Additionally, only a small percentage of the nation's landfills have liners or other systems which prevent contaminants from entering the environment (12:20).

Waste Minimization

Waste minimization programs are gaining widespread approval as a viable solution to the growing waste crisis (1:271). There are two main waste minimization techniques, source reduction and recycling. The EPA considers source reduction and recycling the best techniques available to handle waste management problems (4:72). To lessen the impact of the solid waste stream on the environment, the EPA established the goal of being able to reduce 25 percent of the solid waste stream through source reduction and recycling. Currently only ten percent of all solid waste is managed by recycling techniques (19:9-54).

The idea of waste minimization is not new. Waste minimization and resource conservation were addressed in the *Solid Waste Disposal Act of 1965* (14:101). The problems with implementing waste minimization since that time have been a lack of standard definitions or the institution of a comprehensive policy (9:31-35).

The EPA has tried to establish a comprehensive pollution prevention program by emphasizing waste minimization. A waste minimization program goes through four distinct phases: planning and organizing, opportunity assessment, evaluation of alternatives, and implementation of projects (6:55-110). How does an organization

decrease its generation of solid waste? How can an organization meet the objectives of a waste minimization program?

The following actions are necessary to answer those questions: increase available information, increase planning efforts, increase source reduction efforts, increase recycling efforts, and reduce risks associated with treatment of solid wastes (19:9-54). Waste minimization programs can be beneficial to organizations by improving efficiency in process operations and by reducing waste management costs (5:62-68). Implementation of a waste minimization program is a difficult task, but it does provide many benefits. Alvin Alm summarized the ups and downs of waste minimization best when he said:

> Not only does prevention reduce risks more quickly and predictably, it has the distinct advantage of reducing total exposure of workers, air, surface water, and ultimately the land and groundwater to pollutants. The only problem with this goal is that no one has quite figured out how to make it happen - at least beyond exhortation and technical assistance. (1:271)

Source Reduction and Recycling

Source reduction and recycling are the most popular waste minimization techniques. The best possible way to end the solid waste problem both economically and technically is through source reduction. In many cases, source reduction is relatively inexpensive and easy to implement (9:31-35). The ways to reduce inputs into the waste stream at the source are to modify equipment or processes, improve internal housekeeping practices, and keep equipment running properly and efficiently (4:72).

The Office of Technology Assessment estimates that industry could reduce its waste generation by 50 percent in the next few years by utilizing source reduction techniques (9:31-35). Source reduction

ultimately implies that waste is both avoided and reduced. Unfortunately, because few measurement methods exist there are insufficient empirical data to show the effectiveness of the technique (17:21-29). This lack of data creates a problem, because policymakers want to see assessments that quantify the potential dangers of the solid waste problem before much is done in the way of legislation or regulation (15:113-117).

There is much concern over the institution of source reduction by both industry and environmentalists. One of those concerns is fear of government intervention and regulation. Whether source reduction programs are instituted voluntarily or involuntarily, much is to be gained. The benefits of source reduction will most likely outweigh the consequences. As President Bush said, "Reducing waste at the source is the best way to deal with the problem of a rising tide of garbage and industrial wastes" (9:31-35).

Currently, one of the few issues which individual consumers or industry can impact and provide solutions to is solid waste (17:21-29). Along with source reduction, recycling can help reduce the generation of solid waste. Approximately 60 percent of the states have some form of recycling legislation (13:14). Currently only between ten and thirteen percent of all solid waste is managed by recycling techniques (19:9-54).

The major problem with recycling is the imbalance created between supply and demand. The problem with poor demand of recycled goods stems from: 1) low quality, and 2) costs. Sometimes recyclables cost more than virgin, or raw products; this may be due to greater transportation costs (10:659). Because of the market glut created from

too much supply and too little demand, state and local governments are working with waste management companies to close the gap on the imbalance (2:116-117).

Recycling is not the magic solution that will end all waste management problems. However, with recycling and other waste minimization techniques, the solid waste stream can be greatly reduced and suitable markets for waste reduction products can be created (10:650-662).

Conclusion

Based on the evidence presented in this literature review an urgent need exists to remedy the solid waste problem. One of the ways to remedy the solid waste problem is through the use of waste minimization programs. Two of the most popular waste minimization techniques are source reduction and recycling. By instituting a well managed waste minimization program and utilizing the appropriate techniques, the amount of solid waste that is generated in this country could be substantially reduced.

III. Methodology

Explanation of Methods Used

There are two methods of approach used in this thesis, literature review and policy research. A portion of the literature review has already been presented in chapter two of this thesis. The literature review was conducted to provide sufficient background information for the specific research problem. Through the use of this method, many sources have been reviewed for the definitions, analysis, and impacts of the problems associated with nonhazardous solid waste generation.

The information has shown the scope of the problem and how it effects the nation as a whole. A thorough review of the literature can provide a reasonable interpretation of how the problem applies not only to the nation but also to specific subsections; states, cities, local communities, industries, and government agencies like the Department of Defense.

The second method of approach used in this thesis is policy research. Policy research is defined as the process of conducting research on a social problem and analyzing its impact in order to provide public policymakers with the tools necessary to combat the problem (11:11-14).

Justification of Approaches

There are many methods available for the analysis of research problems. The problem may be addressed either using quantitative analysis of data, qualitative analysis of data, or a combination of

both. Within the confines of this thesis, analysis of the data will be of a qualitative nature. The literature review was a stepping stone into the policy research that was conducted on this particular problem.

The literature review provided background information on the characteristics of nonhazardous solid waste, the impacts and dangers caused by its generation, and the proposed use of waste minimization techniques to alleviate or at least control the problem. The policy research was conducted to reveal problems associated with the method with which the United States Air Force handles minimization of nonhazardous solid waste. This research aims at proposing recommendations to Air Force policymakers for ways to improve current policy as opposed to just problem definition (32:531-545).

In order to suggest feasible solutions it was necessary to understand how the Air Force implements policy in this particular problem area, and what values Air Force leaders have concerning the problem. A thorough review of regulations that pertain to nonhazardous solid waste will show not only the current Air Force policy, but the importance Air Force commanders place on this problem. Additionally, recommendations must be based on the degree to which change can take place. The amount of change instituted can range from minor, short term solutions to comprehensive, long term solutions (11:31).

The following steps were taken in order to understand the environment in which Air Force nonhazardous waste minimization policy is determined. First, it was necessary to identify the problem and narrow the subject to researchable terms. Second, major policy issues had to be identified. T ird, the way in which nonhazardous waste minimization policy is developed had to be analyzed. Fourth, key

personnel involved in Air Force waste management had to be interviewed. Finally, all the information collected had to be evaluated to determine what type of decisions were applicable to the problem statement.

Research Limitations

The methodology used for this thesis is limited by its lack of statistical inferences or applications. The conclusions in this thesis are based solely on the researcher's evaluation of the facts disclosed in the research process. Policy research is routinely criticized for its method of analysis. Policy research uses an empirical, inductive approach to analyze the problem and draw conclusions (11:18-19). Many believe that this is the only proper way to interpret a social problem. Therefore, it is important to understand that while this study does not rely on quantitative analysis, it does attempt to provide answers based on accepted policy research procedures.

Another limitation within this research is the sensitivity of the specific problem. The intent of this thesis is not to determine where nonhazardous solid waste is generated, or the amount that is generated, or even who generates the waste. All these variables have been measured and are well documented. Rather, the intent of this research is to determine what the Air Force policy is concerning minimization of nonhazardous solid waste and if that policy is adequate to combat the problem.

The limitation exists because of the potential implications that the current policy and that those responsible for its implementation inadequately addressed the issue.

Data Analysis

The crux of this research was to develop decision criteria that would assist policymakers in the development of a nonhazardous solid waste minimization policy. In order to develop those tools, investigative questions based on several aspects of the particular problem statement were formulated and answers were sought and obtained.

First, who within the chain of command is most suited for developing or implementing the policy of an Air Force nonhazardous waste minimization? Second, should the policy be adopted as a top down, centralized type of policy or should it be more decentralized and implemented at the local level by the MAJCOMs or individual wing commanders? Third, what particular aspect of the problem should be evaluated?

Any social problem can be divided into four different focus categories; technical, organizational, societal consensus, and power (7:45). This research will concentrate on both the technical and organizational perspectives.

The technical perspective displays the relationship between nonhazardous solid waste generation and its impact on the Air Force. The organizational perspective discusses how the Air Force can develop and implement a waste minimization policy.

In summary, the methods chosen for this research problem are a literature review, which provides the reader with sufficient background information into the specific problem statement, and a policy research, conducted to better equip Air Force policymakers with the tools necessary to combat the problem of nonhazardous solid waste generation.

IV. Overview of Nonhazardous Solid Wastes

The primary purpose of this research is to assist Air Force policymakers in the development of a nonhazardous solid waste minimization policy. To construct a comprehensive waste minimization policy, several aspects of the particular problem statement need to be understood. In this chapter, the characteristics of nonhazardous solid waste and their effects are described. Next, the concept of waste minimization is defined and the process of developing an integrated waste minimization program is outlined. Finally, within the scope of a waste minimization program, the different techniques and methodologies are defined and analyzed. For purposes of this research only two techniques are highlighted, source reduction and recycling. There are additional techniques not directly associated with waste minimization that should be investigated in order to develop a fully integrated nonhazardous waste management program.

Characteristics of Nonhazardous Solid Waste

To characterize nonhazardous solid waste we must look at its composition, size, and effect on the environment. In describing the major components of nonhazardous solid waste, which from this point on will be referred to as NHSW, the environment is limitless. However, this research concentrates on applications to the Air Force environment. In the majority of the literature on nonhazardous solid waste, authors generally refer to the municipal solid waste (MSW) stream which is synonymous with NHSW in this thesis.

The major sources of NHSW include waste from residential, commercial, institutional, and industrial areas. NHSW can be categorized into two main areas; materials and products. Materials are the broader category of NHSW and include paper, yard wastes, metals, plastics, food wastes, glass, and others. The products included in the NHSW stream consist of durable and nondurable goods, containers and packaging, food and yard wastes, and inorganic wastes (21:4). Figure 1 represents examples of products in the NHSW stream.

Products in NHSW	EXAMPLES
Durable Goods	Appliances,furniture,tires
Nondurable Goods	Newspapers,clothing,paper towels
Containers/Packaging	Boxes,bottles,cans,bags,pallets
Food Wastes	Vegetable peelings,corn cobs,uneaten food
Yard Wastes	Grass clippings,leaves,brush trimmings
Inorganic Wastes	Stones,pieces of concrete,potting soil

Figure 1. NHSW Products and Examples (21:2)

Nonhazardous solid waste disposal is regulated under Subtitle D of the Resource Conservation and Recovery Act (RCRA). Municipal solid waste is just one of the many types of waste streams covered by Subtitle D (25:1-4). The Air Force generates many of the same waste streams covered by Subtitle D including; construction and demolition waste, oil and gas waste, and industrial nonhazardous waste. These particular types of waste streams are not considered within the scope

of this research. However, it is important to be aware that not all nonhazardous waste generated is part of the typical Subtitle D Municipal Solid Waste stream.

NHSW is generally characterized by weight and the majority of individuals involved with the issues of waste management also deal with the concept of weight. However, another important estimate characterizing NHSW is volume. Measuring volume is critical in determining how much space is occupied by the different materials. Volume estimates are much more difficult than weight estimates (21:81).

For example, a ton of aluminum cans will weigh the same no matter how they are discarded, however, the question of volume depends on whether those cans are crushed or not. Table 2 shows a comparison between the weight and volume percentages of materials discarded in 1988.

The table shows obvious examples of the differences between weight and volume. For instance, plastics represent only a small percentage of the total weight of NHSW, however the volume they occupy is more significant. At this point it may be helpful to define discards. Discards are the materials in the NHSW stream that remain after recovery for recycling and composting. Discards are usually combusted or disposed in landfills (21:2).

Estimates of the amounts and types of NHSW generated are extracted from models such as the EPA/Franklin model. The EPA/Franklin model was developed in the early 1970's and is updated periodically. This particular model uses a materials flow methodology which examines

the flow of material from the time it is produced until it is disposed. This and other models provide estimates of the total amount of municipal solid waste that is generated nationally.

TABLE 2
COMPARISON OF VOLUME AND WEIGHT PERCENTAGES OF MATERIAL DISCARDS, 1988

	1988 Discards (Mil tons)	Weight % of NHSW total	Volume % of NHSW total	Ratio of vol % to weight %
PAPER AND PAPERBOARD	53.4	34.2	34.1	1.0
PLASTICS	14.3	9.2	19.9	2.2
YARD WASTES	31.0	19.9	10.3	0.5
FERROUS MATERIALS	10.9	7.0	9.8	1.4
RUBBER AND LEATHER	4.4	2.9	6.4	2.2
TEXTILES	3.8	2.5	5.3	2.1
WOOD	6.5	4.2	4.1	1.0
FOOD WASTES	13.2	8.5	3.3	0.4
OTHER	5.6	[illegible]	2.5	0.7
ALUMINUM	1.7	1.1	2.3	2.1
GLASS	11.1	7.1	2.0	0.3
TOTALS	155.9	100.0	100.0	1.0

(21:11)

While this information may be useful to special interest groups and policy analysts at the national level it does not provide useful information to local decision makers (20:75). Local community leaders can appreciate the scope of the solid waste problem by reviewing the national estimates, but to assist them in combating the proliferation of garbage in their neighborhoods they need more specific information. To successfully manage a solid waste problem, information concerning generation in that community is more critical to the local decision makers than national estimates.

Another approach used in estimating quantities of NHSW which, may be more helpful to local communities is site-specific sampling, where individual components of the waste stream are sampled, sorted, and weighed. This methodology is useful in characterizing a local waste stream, provided large samples are taken over several seasons (21:4).

Air Force policymakers can benefit from the philosophy that national estimates provide a good illustration of the intensity of the waste management problem, but these estimates do not define what is problematic at the local or installation level. Air Force installations are part of a larger community such as a municipality, county, city, or state. Air Force installation commanders can benefit by working with their local communities by taking advantage of waste management systems that are currently in place and operating or by using the knowledge the community accumulated in preparing its own waste management solutions.

Throughout the United States, primary responsibility for NHSW management rests with the state and local governments. However, it is evident that there is a desire for more intensive federal involvement. Increased pressure from special interest groups and the general public is causing the Federal government to take a harder look at the issues of solid waste management. Certain special interest groups would like to see a national waste management policy that mandates the use of waste minimization techniques to counter the rapid production of garbage and its potentially harmful affects (20:3-48).

It is the right of all individuals to collectively decide whether the federal government should take responsibility for waste management or continue to let state and local governments handle these problems. Whatever the decision, it is imperative that for any program to succeed it must have the full backing and support of the leaders and people of the affected community, and that goes for the Air Force community as well.

Hopefully, by understanding the characteristics of NHSW the Air Force community can either prevent materials from becoming discards or manage wastes more effectively. The difference between prevention and management is the type of waste minimization techniques used. Source reduction, of course, implies that the generation of waste is reduced by prevention. Recycling is a technique which is used to manage NHSW. Both of these techniques fit within the framework of the waste minimization concept. The following section will define the concept of waste minimization and outline the process of developing an integrated waste minimization program.

Waste Minimization Definition and Process

As defined in the "EPA Manual for Waste Minimization Opportunity Assessments", waste minimization is an umbrella term that identifies the different techniques used in a waste management strategy. In a hierarchical structure the techniques are source reduction, recycling, treatment, and disposal, and their use is gaining widespread approval among individuals most knowledgeable in the field (1:271).

An integrated waste management system using this hierarchal structure is the framework developed by the EPA for the national goals of reducing 25 percent of national municipal solid waste through source reduction and recycling by 1992 (28:2-10). Source reduction and recycling are the preferred methods in a waste minimization program, and as such, are the focus of this research along with their application at Air Force installations.

In developing an integrated waste management strategy it is important to employ all the techniques; however, treatment and disposal are not actually waste minimization methods. The concept of waste minimization suggests that waste is avoided or reduced. The treatment of waste does not necessarily avoid or reduce its volume, but instead insures that the waste no longer presents a threat to the environment or the population. The main emphasis of disposal is to simply transfer the waste from one area to another. For instance, disposal techniques may move the garbage from a sidewalk to a landfill but it will not eliminate the waste (27:1-5). Source reduction and recycling are not a panacea, but an increased emphasis on these techniques along with the use of treatment and disposal can greatly reduce the mounting burden of garbage.

Having established a working definition of waste minimization it is now essential to focus on the development of a waste minimization program. Again, it is important to emphasis that in order to have a fully integrated waste management strategy all techniques must be used. However, this research concentrates on waste minimization and its techniques of source reduction and recycling.

The development of a waste minimization program is no easy task. The EPA has established that four distinct phases should be addressed in constructing a NHSW minimization program; they are, (1) planning and organizing, (2) opportunity assessment, (3) evaluation of alternatives, and (4) implementation of projects. This thesis summarizes the more salient points in each phase. Keep in mind that the intent of this research is not to instruct the Air Force in how to establish a waste minimization program. The intent is to evaluate the current policies and make recommendations concerning a waste minimization program for nonhazardous solid waste utilizing source reduction and recycling techniques for Air Force installations.

Figure 2 shows the four phases used to develop a waste minimization assessment and the primary steps in each phase. This figure represents only an outline of the waste minimization assessment procedure. For a more in-depth description and review of the process, the Jacobs Engineering Group has published a manual that provides a systematic framework that can be used to conduct a waste minimization assessment.

The manual is entitled "The EPA Manual for Waste Minimization Opportunity Assessments". For Air Force applications it is important to be aware that the manual was prepared for waste minimization at the plant and corporate level. Therefore, if implementation of a similar program for NHSW at Air Force installations is considered and assessments are to be conducted, some adjustments are necessary.

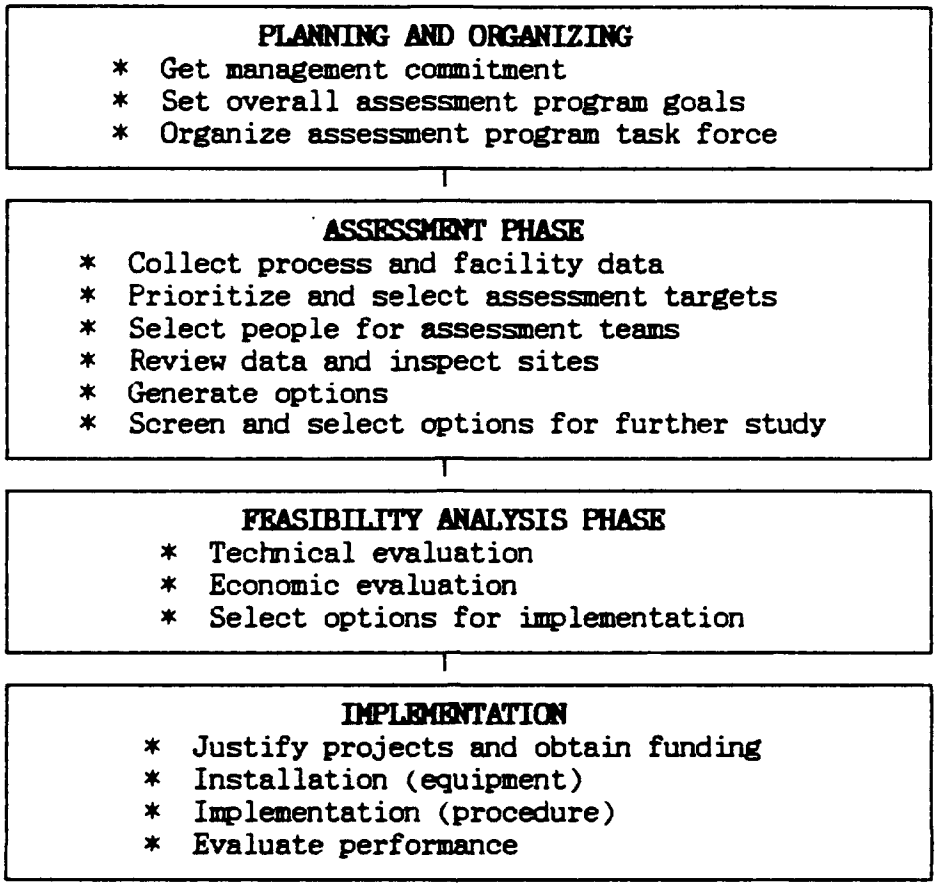

Figure 2. Four Phases of Waste Minimization Assessment Procedure (27:4)

Source Reduction and Recycling

It is clear that something needs to be done to combat this nations growing solid waste problem. The most efficient and effective method of alleviating the strain of a mounting tide of garbage is to simply minimize the amount of trash generated and its adverse effects on the environment and people. This ,of course, is the crux of a NHSW minimization program. As mentioned throughout this research, an integrated waste management program with a hierarchal structure

emphasizing source reduction and recycling techniques is the most appropriate way to minimize the problems associated with nonhazardous and hazardous wastes.

The decline of available landfill space along with rising disposal costs are major problems in solid waste management. Additionally, the lack of commitment on the part of individuals to take responsibility for the waste they generate adds to the problem. Figure 3 shows that the generation of all material discards has increased over the last 3 decades.

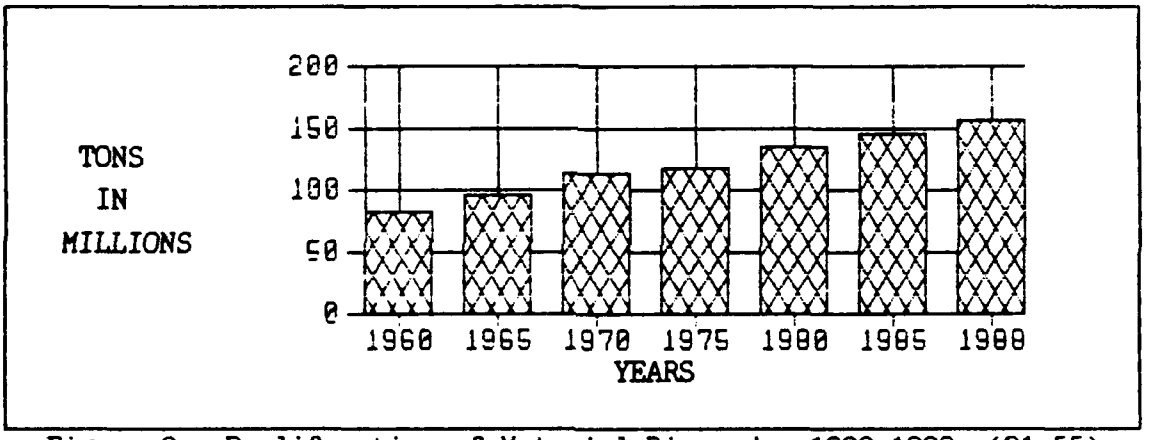

Figure 3. Proliferation of Material Discards, 1960-1988 (21:55)

Given the constraints of declining disposal capacity with increased costs it is imperative to use alternative solutions to combat the problem. Source reduction and recycling are two techniques that offer many distinct advantages for use in NHSW management. Therefore it is appropriate at this time to turn our attention to these minimization techniques and provide a detailed account of each.

An effective waste minimization hierarchy begins with source reduction. Source reduction is simply the ability to eliminate or reduce the volume or toxicity of wastes placed in the solid waste stream. This is accomplished through different methods and/or strategies.

Figure 4 lists some of the methods used in developing source reduction strategies within a waste minimization program. The Air Force could use the majority of these methods if not all in their NHSW minimization program. Details for their implementation are beyond the scope of this thesis.

Source reduction seems to be the most sensible way in which to minimize nonhazardous wastes. Using good housekeeping procedures such as selective buying habits and reusing products or materials that normally would be discarded will dramatically reduce the volume and toxicity of waste. Source reduction provides the advantages of being simple and inexpensive especially when compared to other alternatives. Notwithstanding, the method of source reduction is not being aggressively implemented.

There are two main reasons why source reduction is not very popular. First, consumers have grown accustomed to many conveniences which contribute much to the solid waste stream. All types of products have been designed to make life easier on consumers. A few well documented examples are disposable diapers and polystyrene products such as coffee cups and fast food containers.

INVENTORY MANAGEMENT AND IMPROVED OPERATIONS

* Inventory and trace all raw materials
* Purchase fewer toxic production materials
* Implement employee training and management feedback
* Improve material receiving, storage, and handling practices

MODIFICATION OF EQUIPMENT

* Install equipment that produces minimal or no waste
* Modify equipment to enhance recovery or recycling options
* Redesign equipment or production lines to produce less waste
* Improve operating efficiency of equipment
* Maintain strict preventative maintenance program

PRODUCTION PROCESS CHANGES

* Segregate wastes by type for recovery
* Eliminate leaks and spills
* Redesign or reformulate end products to be less hazardous
* Optimize reactions and raw material use

Figure 4. Source Reduction Techniques (4:73)

While these products were originally designed for convenience and possibly safety or health reasons the impact on the waste stream was not carefully considered. The availability of such products has given consumers the opportunity to spend less time on the mundane and trivial and spend more time on the exciting and enriching, but on the other hand it has generated a throwaway mentality that will be difficult to change (26:5).

Another reason for the lack of support given to source reduction activities is visibility. The results produced by source reduction are difficult to see and measure, especially in the short run. A lack of empirical evidence can prevent policymakers from committing resources to programs utilizing this waste minimization technique (9:31-35). Since source reduction ultimately prevents wastes

from being generated there is not much in the way of adverse environmental or health effects to be measured or to remedy. In order to be effective, source reduction efforts require long term commitments by the organization involved.

The difficulty with this commitment in the Air Force or other services is the high turnover rate of personnel throughout all echelons of command. Air Force policymakers need to consider the connection between commitment and turnover when trying to establish a NHSW minimization program. Even though the benefits of source reduction might seem nebulous there are examples of organizations that have had great success. 3M and Dow Chemical are two companies that have adopted aggressive source reduction programs that are successful and paying regular dividends because of widespread commitment to the goals of the program (9:31-35).

Source reduction is a matter of prevention rather than management. As such, program development and operation are more difficult due to the inability of seeing the results of the technique as opposed to recycling and other methods. The challenge facing Air Force commanders is how to promote source reduction activities.

The EPA has suggested three categories for promoting source reduction; regulation, incentives/disincentives, and education and recognition (26:8). The first category is regulation, one that should be easy for all Air Force personnel to understand. Regulation is simply mandating some type of action that will either prohibit or control the generation of NHSW. At the time of this writing there were no Air Force publications that regulated solid waste management and the use of any waste minimization techniques. There are manuals and

pamphlets that address solid waste management, but they are not directive in nature. Additionally, these publications are outdated and for the most part ignored.

The next category is the use of incentives and disincentives. Most references to this option are economic, that is, financial incentives such as increased revenues or reduced costs or financial disincentives such as taxes or fees. While economic incentives and/or disincentives are widely used and probably most effective, there are other ways to incite individuals or organizations to practice source reduction. These other methods are normally discussed in the final category, education and recognition. Education is fundamental to the establishment of any program. People need to be educated in order to fully understand the purpose of the program and to make it work efficiently and effectively. Once individuals are educates and consciously participate they can be rewarded for their efforts through either the economic incentives discussed above or through other means which are of a more intrinsic nature (29:20).

Each of these categories could be used separately or in concert with one another. The important thing to remember is that each category has its own particular pros and cons. These must be weighed against each other to formulate a policy for source reduction which is beneficial to the organization in question.

The EPA pamphlet, "Source Reduction as an Option for Municipal Waste Management" outlines these categories and presents specific options available within each. Additionally, the pamphlet discusses the pros and cons that help and hinder each category.

Most communities that have responsibilities for waste management have only a few options available to control or eliminate waste generation. One, of course, is source reduction which is the primary technique in the EPA's hierarchal waste management strategy. When used properly, source reduction is by far the most effective because it slows the depletion of environmental resources, minimizes the volume and toxicity of waste, and extends the useful life of available waste management capacity (28:18).

Other waste management options available to communities include treatment and disposal which were discussed previously and were shown to be the least preferred methods and are not actually waste minimization activities. Finally, there is the option of recycling. Much has been said about this topic, especially in the last 20 years. Recycling is the method which immediately follows source reduction within the EPA's hierarchy.

As has already been stated, this research focuses on the application of a waste minimization program for NHSW utilizing source reduction and recycling techniques for Air Force installations. Therefore it is appropriate at this time to highlight the activity of recycling.

Recycling is more a management technique then a matter of prevention. Recycling enables waste materials such as paper, plastic, and glass to be reused for some useful commercial or industrial purpose (4:71-75). A successful recycling program depends on: (1) an efficient collection and separation process, (2) the amount of participation by the organization or community involved, and (3) the price received for the recycled materials (20:135-217).

Recycling provides many of the same benefits as source reduction. Additionally, recycling has the advantage of being able to generate additional revenue or in the case of the Air Force a possible offset in waste management costs. If a recycling program is carefully developed and managed effectively it can make a profit. It is not the intent of the author to suggest the Air Force apply a waste minimization program using recycling to reap financial rewards, however the possibility does exist and should be researched further. The DoD is not a profit oriented organization, thus there are probably restrictions that apply to this application and investigation of such restrictions is well beyond the scope of this thesis and the expertise of the researcher.

At least 30 states and the District of Columbia have enacted laws which require statewide recycling plans. It seems as if everyone is becoming involved in recycling. Everyday citizens are suddenly becoming more aware of the dangers created by excessive waste. If this trend continues it won't be long before all states have some type of legislation dictating the use of waste minimization techniques such as source reduction and recycling. Air Force installations as part of larger communities are or will be subject to these laws.

According to 1988 figures only 12.9 percent of the MSW generated was recovered for recycling purposes (21:74). The current figure is still estimated between ten and thirteen percent. These figures represent that there is great potential for recycling efforts.

However, there are still obstacles that must be overcome. First, the development of markets for recyclables is paramount. As mentioned earlier, there has been market gluts for some recycled

products. The imbalance between supply and demand is being addressed by federal and state legislative bodies. For example, government procurement programs are mandating the purchase of recycled materials such as paper (13:3). Another obstacle is the ability to develop a program that is right for the needs of a particular community. Each community is particular and must tailor its recycling programs to fit its own needs and goals.

How then should a recycling program be developed? It must be understood that initiating a recycling program is no easy task. There are attitudes and opinions that must be changed, economic variables to be considered, and recycling options that are best for the particular community that must be evaluated (24:4).

There are several issues that need to be addressed before implementing a recycling program. First, the waste stream needs to be analyzed to determine its source and contents. Next, all the waste management options that are available must be evaluated to select the most beneficial in terms of cost and effectiveness.

It is possible that recycling may not always be the best alternative given the uniqueness of each community, but this is usually the exception more than the rule. The third issue is to determine to what extent the local community or state is involved in recycling efforts, and that includes any Air Force installation located within the community or state.

Since Air Force installations are very much a part of the local community it is in their best interests to become aggressively involved in any coordinated waste minimization efforts with their local community. One, the recycling infrastructure may already exist and

make recycling activities easier. Second, this type of involvement can strengthen community relations (8:22-28).

The next three issues were mentioned earlier and represent the biggest challenge in establishing a recycling operation. First, the attitude of the public towards a recycling component needs to be addressed because it can have a dramatic impact on the level of success or failure experienced within the program.

Once it has been determined that a recycling program is needed and wanted, the next step is to determine which recycling options are best for the community in question. These options are discussed in more detail later in the chapter.

The final and possibly the most important consideration in establishing a recycling operation is marketing recycled materials. As mentioned previously, one of the major problems with recycling is the imbalance created between supply and demand. There is more material recycled than the market demands, thereby creating a surplus in that sector of the market (20:135-217).

This particular problem may not directly impact Air Force installations, especially if they are involved with a local community program that is successful. If the installation does not have that advantage or has to recycle materials within the confines of the installation then markets will have to be found or created. This particular process may be beyond the capabilities of installation commanders and their staff. Therefore, Air Force leaders may have to find a way to perform this marketing task on a much grander scale.

What recycling options are available to a community or installation? Options can be divided into two categories; what to recycle and how to recycle. The first category, "what to recycle", is deciding what materials from the waste stream will be included in the recycling program. The second category, "how to recycle", includes the process of sorting wastes and choosing the appropriate method of collection (24:4-5).

Once the waste stream has been analyzed it is then necessary to determine which wastes will be recycled. Again, recycling may not be the best answer for minimizing all the materials found in the waste stream. All materials in the waste stream possess unique characteristics, each has a distinct technical makeup that must be considered and each has its own market or in some cases, lack of market. These characteristics need to be considered before embarking on a full scale recycling program (16:77).

Theoretically all materials can be recycled, but is it feasible to try and recycle all the materials found in the waste stream? This is a question Air Force leaders must ask themselves. There is no easy answer, however a careful analysis based on a comprehensive waste management assessment can provide the tools necessary to make those decisions (see figure 2).

It may be impractical from both an economic and managerial viewpoint to try and recycle all materials found in a communities waste stream. However, a comprehensive waste minimization program that uses source reduction and recycling techniques, if managed effectively, can greatly reduce the amount of NHSW placed in the environment.

To put the first category of "what to recycle" into perspective, lets consider a purely fictional example. After a careful assessment, Air Force leaders have determined that bases located in the northeastern portion of the United States can recycle glass, plastics, and yard wastes, but not paper. Why?

Due to the weight of glass its disposal costs are quite high in this part of the nation and recycling was determined to be more economically desirable. Plastics recycling technology is very advanced and presents a more viable option than disposal in landfills. Additionally, the northeast has a yard waste composting program that is the pride of the nation, therefore composting has an advantage over placing yard wastes in landfills or incineration.

Paper was not considered as part of the recycling effort because of the current market situation. A market glut for paper has been created and there is more supply than demand. Even though the other options for managing paper waste are less desirable, it was not economical to recycle paper.

Overall, the materials that were determined to be recyclable had available markets and technology to effectively minimize their impact on the NHSW stream. Through recycling activities, the use of less desirable disposal methods were prevented, landfills were not overburdened, and financial gains or cost reductions were realized. Unfortunately, paper recycling was not an option. With proper education and incentives however, source reduction techniques could lessen the impact on paper on the waste stream.

Keep in mind that this was an example constructed to show the considerations made in deciding what materials need to be part of a recycling program. Also, for purposes of illustration, a centralized decision making authority dictated the program elements for all bases in the northeast portion of the United States. The process is not that simple. As was mentioned earlier, every community or installation is unique and the institution of a waste minimization program needs to be tailored to their individual needs.

Therefore, it might not be advantageous to have centralized decision making authority unless a well trained, dedicated staff is available to make the proper assessments and determinations for individual installations. It may be more prudent for Air Force leaders to issue policy and guidance on waste minimization allowing installation commanders the flexibility to develop their own programs, within certain established guidelines.

Once a community or installation has determined what it will recycle it must now direct its attention on how to recycle. This category of a recycling component includes the process of sorting wastes and choosing the appropriate method of collection. There are basically two methods involved in collection; curbside collection and drop-off centers. There can be variations of each method or combinations of both. Also, each method has unique sorting requirements that need to be considered.

Whether a community chooses a curbside or drop-off collection process the issue of source separation must be addressed. Source separation is defined as setting apart or "separating" recyclable materials from one another at the point where they are generated.

Depending on the type of program, materials can be segregated into their own specific containers or mixed with other similar materials for separation to be done away from the point of generation (22:65).

In a curbside collection program recyclable material is collected in the same way as normal trash. Recyclable materials are placed at the "curb" at either residential or business areas and refuse companies collect the materials for further processing. Collection can occur on either the same or a different day than regular trash collection. Curbside collection programs are more costly than drop-off centers, but experience more success.

In a drop-off program, individuals or businesses will bring recyclable materials to a centralized drop-off center. These centers can be in the form of dumpsters sitting in a parking lot to staffed collection centers. Source separation at drop-off centers ranges from segregating all materials and placing them in their respective containers to commingling materials for later separation. While drop-off centers are more economical than curbside programs they normally do not yield as much recyclable materials (24:5).

The Air Force is unique in that it maintains an organizational structure where individuals are employed, but also maintains a community structure where those same individuals and their families can live. This combination enables Air Force installations to participate in two types of recycling program options.

First, the residential type of recycling activities already discussed which include the curbside and/or drop-off collection processes. Second, Air Force installations can participate in commercial programs which recycle materials such as office paper,

corrugated cardboard, glass, metals, oil, and pallets to name just a few.

The Air Force may have a handle on some commercial commodities, for example the precious metals recovery program. However, Air Force installations could be more involved in other areas such as office paper recycling which has been proven to be very successful. In 1990 the EPA published a booklet entitled "Office Paper Recycling: An Implementation Manual" which is a good source for the developement and operation of an office recycling program.

There is one final topic concerning recycling that needs to be addressed, Materials Recovery Facilities (MRFs). MRFs are centralized facilities that separate and sort wastes and process them for resale. Because of the the lack of landfill space and the proliferation of recycling programs, experts have predicted that MRFs will increase from the current number of 40 to 60 to approximately 500 by the year 1995 (3:54-55).

Because the DoD is currently facing budget cuts along with force and base restructuring, issues such as MRFs may have some applicability in the future for the DoD. MRFs are important because they enable recyclable materials to be collected and processed more uniformly (22:69).

The entire last section of this chapter has been devoted to the analysis of source reduction and recycling techniques. Before concluding this chapter it is appropriate to enumerate the advantages and disadvantages of a waste minimization program utilizing source reduction and recycling techniques. Figure 5 outlines the advantages relating to a waste minimization program while Figure 6 outlines the

disadvantages. Both techniques share many of the same traits. However, any item presented that represents one technique more than the other will be highlighted by either an "(S)" for source reduction or a "(R)" for recycling.

ADVANTAGES

1. Economic Benefits

(R) * increased revenue from recycling or resale of products
(S) * reduced storage and handling costs
* reduced waste transport and disposal costs
(S) * reduced raw material costs
* increased production capacity
* lower health and safety costs
(S) * improved product quality

2. Environmental and Health Benefits

* conservation of critical landfill space
* conservation of natural resources
* reduction of the volume and toxicity of pollutants to environment

3. Program Management

(S) * low level of technical expertise required
(R) * wealth of information available on techniques and program management
* based on program elements required, programs can be relatively inexpensive compared to other waste management alternatives

4. Improved Public Relations

* waste minimization efforts by Air Force installations will foster better public relations with environmentally conscious communities

5. Liability Reduction

* less waste - less liability to environment and community

6. Regulatory Compliance

Figure 5. Advantages of a Waste Minimization Program Utilizing Source Reduction and Recycling Techniques

DISADVANTAGES	
1.	Economic Costs
	* start-up costs for planning, waste and market assessments, and publicity
(R)	* operating costs for labor, equipment, maintenance, supplies, training, and administration
2.	Environmental
(R)	* recycling is not always gentle on the environment
(R)	* reprocessing of wastes can generate other hazards such as lead or cadmium into ground water or fly ash
3.	Program Management
	* must deal with public attitudes that still gravitate towards waste rather than conservation
(S)	* difficult to gain support because of lack of empirical evidence
	* leaders wanting short term solutions to long term problems
(S)	* evidence of success possibly not realized for long time

Figure 6. Disadvantages of a Waste Minimization Program Utilizing Source Reduction and Recycling Techniques

In conclusion, this chapter presented an overview of three main topics that pertain to nonhazardous solid waste. First, the characteristics of NHSW were discussed. By understanding the composition, size, and effects of NHSW Air Force leaders become better equipped to manage if not prevent the problems associated with NHSW generation. How to prevent and/or manage NHSW was addressed in the second topic area.

The second topic defined the concept of waste minimization and outlined the process of how to develop a comprehensive and integrated program. Waste minimization is an umbrella term that was used to identify different techniques in a waste management strategy. In developing a strategy the two most widely preferred techniques are source reduction and recycling. There are other techniques, but this research effort focused on these two only. The development of a waste minimization program is no easy task. However, the chapter outlined the four phases and the primary steps necessary for program evolvement.

The final topic highlighted the two preferred waste minimization techniques, source reduction and recycling. Source reduction implies that waste is avoided and/or reduced at the source of generation through preventative methods. Recycling is a management technique which enables waste materials to be reused for some commercial or industrial purpose.

V. Conclusions and Recommendations

Conclusions

Based on the research presented it is evident that there is a mounting nonhazardous solid waste problem. To effectively combat this problem one must consider a variety of different variables and realize that there is no "one" best solution to all possible situations. However, the developement of a comprehensive waste minimization program utilizing source reduction and recycling activities is considered by many to be the most effective and efficient method of decreasing the solid waste burden.

Developing a NHSW minimization program is no easy task, especially for an organization as complex and diverse as the Air Force. However, the payoffs generated from a well planned and executed program are sorely needed and desired. Some of those payoffs include economic benefits, environmental and health benefits, improved public relations, liability reduction, and regulatory compliance.

The two most preferred waste minimization techniques within a hierarchal structure are source reduction and recycling. The best possible situation is to simply avoid generating solid waste materials, this is source reduction, and is the most preferred technique. Source reduction is less costly than recycling operations but is difficult to implement because of a lack of empirical evidence and short term results. Recycling is a desirable function and has many benefits, however recycling operations tend to be site specific and require good management skills and commitment.

This research effort is intended to provide a solid background of what NHSW is and the proper ways to alleviate its hazards. It is not all-inclusive nor does it provide all the answers. Hopefully the product this research will attract is the attention of Air Force policymakers to an issue that is largely ignored. During the last decade the main emphasis the Air Force has placed on environmental issues concerns hazardous wastes and with good reason. Due to the high health risks involved, it is critically important to rid the environment of as many hazardous substances as humanly possible.

But it is unwise to ignore the problems associated with NHSW. At this point it is possible to simply remove garbage from an installation and dispose of it in a landfill, but there are problems with this philosophy. Landfill space is declining rapidly and disposal costs are rising dramatically. Air Force leaders must consider other options in order to combat the current problem, otherwise the problem will escalate. To conclude, the scope of this research was to convince Air Force leaders that the application of a NHSW minimization program utilizing source reduction and recycling techniques for Air Force installations is needed urgently.

Recommendations

The single most important recommendation to be made is that Air Force efforts and policy towards waste minimization should be expanded to include NHSW. The Air Force has the expertise and knowledge available to develop and implement a fully integrated NHSW minimization program. Unfortunately, the proper emphasis has not been given to the subject matter. A NHSW minimization policy for Air Force installations

needs to be developed along with the proper guidance necessary for commanders to institute these programs.

To develop a policy for NHSW minimization the degree of change must be addressed. Air Force leaders need to understand that a program such as this must be comprehensive and long term in its scope. Any benefits derived from a waste minimization program, especially one using source reduction, may not be realized for a number of years.

Due to site-specificity, the need for a decentralized decision authority is necessary. This means that installation commanders should be given the flexibility to develop and manage their programs. However, an agency that is adept in NHSW management should be established in order to issue and monitor policy and program guidelines. As long as commanders meet the minimum requirements outlined in the policy they can be as creative as needed when it comes to program developement and implementation. This type of structure acknowledges quite easily the concept that not all installations and their waste streams are alike, and therefore require site-specific programs emanating from broad based policy.

Installation commanders along with their base environmental agency should coordinate with the local community and form joint projects if possible. This would create the necessary infrastructure for the entire community to more readily reduce the amount of nonhazardous solid waste. In addition, public relations could be improved and the installations could be setting the example for other communities to follow.

As previously mentioned, many bases have established recycling programs that are managed through the Morale, Welfare, and Recreation (MWR) division. This is a step in the right direction, however these programs are not large enough in scope to significantly affect the potential problems associated with NHSW. Possibly through the use of the base Environmental Protection Committee (EPC) more substantial programs could be developed. The EPC should not limit itself to recycling programs. It should consider source reduction methods and other solid waste management issues.

A topic that was briefly described earlier was Materials Recovery Facilities (MRFs). The Air Force should consider converting unused military facilities into MRFs based on the potential growth associated with recycling and the increase in MRFs. Further research in this area should be considered.

Another recommendation concerns the types of materials and/or products that an installation should consider in its NHSW minimization program. Some of the more familiar materials usually considered include glass, plastic containers, aluminum beverage cans, paper, and oil. It is wise to carefully assess the waste stream in question because of the unlimited amount of trash that could be minimized.

The attached appendices should provide helpful information for developing and implementing a NHSW minimization program. Other types of materials that should be considered and could be important in a NHSW minimization program are: transportation packaging and storage materials, office paper recycling, and lawn trimmings and food wastes for composting.

In developing an Air Force NHSW minimization program, a set of decision criteria must be constructed to support the decision making process. The following criteria should be addressed before embarking on any waste management program. One, what is the size of an installation based on its population in the work force and in residential areas. Keep in mind that different size communities generate different amounts of wastes. Second, what is the installations primary mission, flying or non-flying. Each situation generates different types of waste streams and the approach to minimization may not be the same. The third decision criteria is the type of local environment. The considerations here include the size of the local community, their laws concerning waste management, the attitude of the community towards waste minimization, and the relationship between the community and the installation. Finally, what is the extent of an installations current waste minimization policy and practices. Basically, does the installation have a program or not. If a program exists what are the details.

In summary, the Air Force has taken great strides in improving the quality of life for its members. We have seen the importance of emphasizing physical fitness, non-smoking policies and other programs aimed at improving employee productivity through better health. By adopting a comprehensive NHSW minimization program we can reduce potential health hazards, increase productivity, promote more effective and efficient processes, and increase revenues or offset costs.

The bottom line is that there are more benefits than costs regarding NHSW minimization utilizing source reduction and recycling techniques, so what are we waiting for?

Appendix A: U.S. EPA Offices

REGION 1

J.F.K. Federal Building
Boston, MA 02203
(617) 573-5700

REGION 2

26 Federal Plaza
New York, NY 10278
(212) 264-0002

REGION 3

841 Chestnut Street
Philadelphia, PA 19107
(215) 597-0982

REGION 4

345 Courtland Street N.E.
Atlanta, GA 30365
(404) 347-3433

REGION 5

230 South Dearborn Street
Chicago, IL 60604
(312) 886-7452

REGION 6

First Interstate Bank Tower
1445 Ross Avenue
Dallas, TX 75270-2733
(214) 655-6760

REGION 7

726 Minnesota Avenue
Kansas City, KS 66101
(913) 236-2852

REGION 8

One Denver Place
999 18th Street
Denver, CO 80202-2405
(303) 293-1667

REGION 9

215 Fremont Street
San Francisco, CA 94105
(415) 974-8926

REGION 10

1200 Sixth Avenue
Seattle, WA 98101
(206) 442-2857

U.S. Environmental Protection Agency
401 M Street S.W.
Washington, D.C. 20460

RCRA/Superfund Hotline: 1-800-424-9346

Appendix B: Industry Contacts for NHSW

Aluminum Association
900 19th Street N.W.
Washington, D.C. 20006
(202) 862-5100

Aluminum Recycling Association
1000 16th Street N.W.
Suite 603
Washington, D.C. 20036
(202) 785-0951

American Paper Institute
206 Madison Avenue
New York, NY 10016
(212) 340-0654

Council on Plastic and Packaging in the Environment
1275 K Street N.W.
Suite 300
Washington, D.C. 20005
(202) 789-1310

Environmental Defense Fund
257 Park Avenue South
New York, NY 10010
(212) 505-2100

Food Service and Packaging Institute
1025 Connecticut Avenue N.W.
Suite 513
Washington, D.C. 20036
(202) 347-3756

Glass Packaging Institute
1801 K Street N.W.
Suite 1105-L
Washington, D.C. 20006
(202) 887-4850

Keep America Beautiful, Inc.
Mill River Plaza
9 West Broad Street
Stamford, CT 06902
(203) 323-9897

National Association for Plastic Container Recovery
5024 Parkway Plaza Boulevard
Suite 200
Charlotte, NC 28217
(704) 357-3250

National Oil Recyclers Association
2600 Virginia Avenue N.W.
Washington, D.C. 20037
(202) 333-8800

National Solid Waste Institute
10928 North 56th Street
Tampa, FL 33617
(813) 985-3208

National Solid Waste Management Association
1730 Rhode Island Avenue N.W.
Suite 1000
Washington, D.C. 20036
(202) 659-4613

Steel Can Recycling Institute
Foster Plaza X
680 Andersen Drive
Pittsburg, PA 15220
(800) 876-SCRI

Technical Association for the Pulp and Paper Industry
15 Technology Parkway
Norcross, GA 30092
(800) 332-8686

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Vita

Captain Brian McDermott was born on 13 August 1960 in Philadelphia, Pennsylvania. In 1980, he enlisted in the U.S. Air Force and had tours of duty at Randolph AFB, Texas and Andersen AFB, Guam. After separating from the Air Force he attended the University of Texas at Arlington, graduating with a Bachelor of Business Administration (specialty: Finance) in December 1986. In January of 1987 he attended Officer Training School and received his commission in the U.S. Air Force. His first assignment was as a Logistics Plans Officer for the 436th Military Airlift Wing at Dover AFB, Delaware. While at Dover he performed duties as the OIC, Wing Mobility until April 1990. He was then selected to attend the School of Systems and Logistics, Air Force Institute of Technology, in May 1990. Captain McDermott has been married for nine years to his wonderful wife Wendy and they have one daughter, Catherine.

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13. ABSTRACT (Maximum 200 words) This nation has fallen victim to its own excessive behavior and has created an overabundance of trash, referred to in this thesis as Nonhazardous Solid Waste (NHSW). This situation has created environmental and health problems that can no longer be ignored. All types of communities are affected including Air Force installations. Unfortunately, the AF does not currently have a long-term waste management policy or program regarding NHSW minimization. This research concentrates on the application of a NHSW minimization program for AF installations using the two most preferred methods, source reduction and recycling. The development of a comprehensive waste minimization program using the techniques described is the most effective and efficient way to decrease the solid waste burden. The construction and implementation of these programs is not easy, especially for an organization as complex and diverse as the AF. However, the payoffs from a well planned and executed program far outweigh any costs.

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